A REVIEW PAPER ON COMPARATIVE ANALYSIS OF RC STRUCTURE WITH AND WITHOUT OUTRIGGER USING STEEL BRACING

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Abstract:
Tall building development has been rapidly increasing worldwide introducing new challenges that need to meet through engineering decision. As the height of the structure increases the stiffness of the structure reduces. Hence to develop the performance of the structure under seismic loading, outrigger system is proposed in the current study of work. This system is commonly used as one of the structural system to effectively control the excessive drift due to lateral load, so that during small or medium lateral load due to either wind or earthquake load, the risk of structural and non-structural damage can be minimized. In the current work, contain a comparative study on regular building with and without outrigger and irregular building with and without outrigger with centrally rigid shear wall and steel bracings as outrigger. The modeling of the structure is done using "ETABS" program. The analysis of the model is carried out by equivalent static method and response spectrum method. The stiffness and efficiency buildings characteristics of the structure is measured in terms of lateral displacement, drift, base shear and fundamental natural period for different types of buildings to provide stiffness against static and dynamic loads. The parameters should be minimized to prevent damage to the. In this paper, the effect of outrigger on key seismic design parameters of tall buildings with braced or shear wall core is studied. Based on the results of modal response spectrum (MRS) and nonlinear time history (NLTH) analyses of 44 models with braced or wall core, discussed in the companion paper and pushover analysis and presented in this part, the effect of outrigger and its placement level on parameters of seismic design including response modification factor R, overstrength factor Ω0, deflection amplification factor Cd, and damping ratio of structures are studied. New local measures for Cd and Ω0 are proposed based on the NLTH results. It is observed that outrigger results in greater increase in strength and stiffness of structures with wall core than buildings with braced core, but decreases the ductility of both systems. The obtained R is less than the values given by the code in most cases. For the main structures without outrigger, using the code prescribed value for Cd underestimates the real displacement of the structures with wall core and overestimates it for those with braced core. Outrigger results in increasing Cd of structures with braced core and reduction of Cd in those with wall core. The considerable variation of two proposed measures for Cd shows the inappropriateness of application of a single value of Cd for all stories. Outrigger increased the damping ratio of buildings with shear wall core considerably.

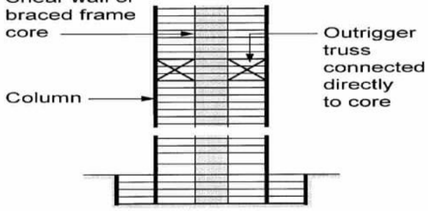
Introduction The development of tall building has always fascinated mankind from the ancient times. From the past, tall structures have always seen as a symbolic example of power and development. The challenging task in the construction field is to assemble the tall building. The design of tall building is based on analysis of models with experience and fundamental mechanics. As the height of the building increases the risk of horizontal and vertical load forces also increases. The moment resisting frames and braced core at certain height becomes inefficient to provide stiffness against wind and seismic loads. The lateral deflections due this load should be prevented for both structural and nonstructural damage to achieve the building strength and also stiffness against lateral loads in the analysis and design of tall building. To increase stiffness action against wind and seismic load outriggers are provided by the shear core with exterior frames in tall buildings. The effective depth of the structure is increased, when the outriggers are placed. The work is carried out to know the behavior of outriggers in the tall buildings. The building is analyzed for 20 storey building mainly four types of buildings are used and they are regular building with and without outrigger and also vertically irregular building with and without outriggers are used. In the proposed building instead of core wall shear wall is provided with columns inserted in it. The outrigger is made up of steel bracing. The analysis is carried out on building with varying zones using ETABS software (Engineering three dimensional analysis of structure) and results are generated with various parameters. The equivalent static analysis method and dynamic analysis method is adopted for analysis. The results generated are tabulated and graphed. The values are compared with different type of buildings for the lateral stiffness by seismic forces. The behavior of different types of building is known with various zones and also the effect of lateral load on the building when outriggers are provided. The lateral stiffness of the outrigger building is shown in this work. The primary purpose of the structural system is to effectively transfer the gravity loads without causing damage to the buildings. The gravity loads are mainly dead load, live load and snow load which affect the tall buildings. Apart from these loads the building is also subjected to horizontal lateral loading caused by the action of wind and earthquake forces. These lateral loads leads to huge damage to tall building by producing high stresses by causing vibration or sway movement. Therefore it becomes important that the tall buildings should be provided by necessary strength by installing these structural systems. The tall structure is provided with shear walls which have columns; these columns are installed in the shear wall primarily to carry the gravity loads. The shear wall in the building will provide strength and lateral stiffness to the building in the direction of building orientation by reducing the lateral sway and damage to the structure. The outriggers with steel bracings are provided which increase the axial stiffness with the peripheral columns to resist the overturning moments. The system is very effective to resist the lateral loads. As the concept of outrigger and bracings are combined it decreases the bending moment in beams and shear forces in columns by increasing the column axial compression. The structure consists of central core comprises shear wall with horizontal girders or cantilever type trusses called outriggers made up of steel bracing, connecting to the outer columns of building. The shear wall is located centrally by extending outriggers on both sides of the columns. When the horizontal loads acts on the building the outriggers resist the rotation of the core wall or shear wall by causing the lateral deflection and minimizing the effect of the loads on the building. The effective depth of the building is increased when it acts as a vertical cantilever by inducing compression in the leeward columns and tension in windward columns .The outriggers are are very effective in increasing its flexural stiffness while the shear wall in the building will provide the resistance to shear. There are two types of outrigger system, they are

1.Conventional outrigger Concept

2.Virtual outrigger Concept

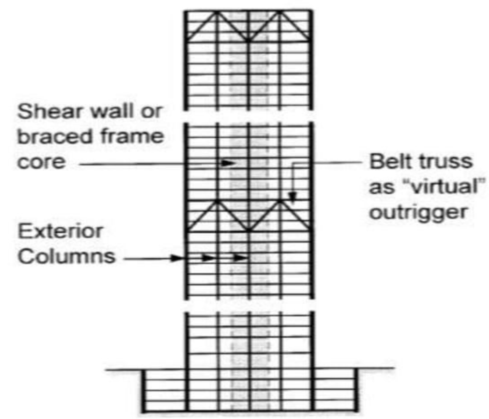
Conventional outrigger Concept:

In this concept of outrigger in tall buildings, the outriggers are connected to braced frames or shear wall directly at the core. But not necessarily to the columns located at outer edges of the building.



virtual outrigger concept:

In this concept the outriggers connecting core and perimeter systems is eliminated directly and instead a belt truss is used with a combination of stiff and strong diaphragms. The moment occurred in the core is converted into horizontal couple in top and bottom of the floors of basement



In recent past year's reinforced concrete buildings have became common in urban places. The main challenge in tall building is to resist the wind and earthquake forces. The reinforcing steel bars and concrete are the two key materials used in reinforced concrete building. A typical RC tall building is made of horizontal and vertical member and supported by foundation on rest of the ground. To resist the earthquake forces the RC frames plays a vital role. The inertia forces generated by earthquake shaking are proportional to mass of the building. The mass of the building is present at the floor level, the inertia forces due to earthquake is always induced at floor levels. As the forces from top of the building are transferred to the base of the building, the case of the building is more affected by the earthquake induced forces.

About project introduction: -

The horizontal deformations suitable to this load must be avoided structural with unstructured damage in arrange toward find the strength and rigidity of the structure alongside the lateral loads in the analyze along with intend of tall buildings. To raise rigidity, the cut core ensures operation against wind and seismic loads with external frame within large buildings. The actual strength of the structure increases while outrigger is added. The work to be done by carrying outrigger in large building. The structure be analyze for a 30 storey structure, there are four types of building they areuse of symmetrical building s are use of symmetrical buildings with and without outrigger and an irregular symmetric building with and without outrigger. The proposed building, instead of the original wall, provides a cut wall through columns insert inside it. The outriggers are made of steel bracings. The analysis is made by E-tabs software along with result to be generated by different parameter. The equivalent static method with dynamic method to be adopted for analysis. The results are generated, tabulated and graphed. The values are compared with different building used for lateral stiffness in the seismic force.

The performance of various type of structure is identified through different zone with it of lateral load on top of the structure while outrigger is provided. The main use of structural system is to transfer the gravity loads without causing any damage into buildings. The main effective loads of buildings are

- Dead load
- Live load
- Wind load
- Seismic load

The structure is subjected toward parallel lateral building cause due to the act of wind and earthquake forces. The lateral load lead can break to high buildings through produce huge stress searthquake forces. The lateral load lead can break to high buildings through produce huge stress through causing vibration. So that it becomes important for building supposed to be provide by essential strong point with install of structural system.
The tall structure is provided with shear walls which have columns, these columns are installed in the shear wall primarily to carry the gravity loads. The shear wall in the building will provide strength and lateral stiffness to the building in the direction of building orientation by reducing the lateral sway and damage to the structure. The outriggers with steel bracings are provided which increase the axial stiffness with the peripheral columns to resist the overturning moments.
The theory of outriggers and bracings are combined it decreases the bending moments in beams and shear force in column through increasing the column axial compression. The building consists of inner core comprises shear wall by horizontal girder or cantilever sort of truss called outriggers made of by steel bracing connecting to the outer columns of building. The shear wall is mainly located at centre by extend of outriggers on equally on the side of column. While parallel load act resting on the structure then outriggers resist the rotation of the inner center wall or shear wall by causing the lateral deflection and minimizing the effect of the loads on the building.

Literature review:

Po Seng Kiran and Frits Torang Siahaan (2001)

Researchers have worked on the idea to increase the stiffness and make the structure proficient under wind as well as seismic load by introducing outrigger and belt truss system connecting core to exterior column. In this research work authors have studied the application of diagonal outrigger and belt truss with different configurations. They have carried out the analysis on a 40 storied 2-dimensional models and 60 storied 3D models subjected to wind load by introducing outrigger and belt truss systems with eight different configurations by varying the locations of outrigger as per the British standard. Similarly, 60 storied 3- dimensional models subjected to earthquake load by incorporating outrigger and belt truss system with 5 different configurations by varying Locations, numbers and height of diagonal outrigger beam and belt truss.
A comparative study has been carried out to examine the reduction in lateral displacement. Researchers have also focused on to determine the optimum location of outrigger. Investigation of this research paper have found that 65% and 18% maximum reduction in displacement is attained in the 40 storied 2D and 60 storied 3D models subjected to wind load by providing two outriggers. The first outrigger is assigned at the top and second at the mid height of the structure

Herath N et al., (2009)

In this paper they have said a special attention should be given for high rise RC buildings, since tall buildings often accommodate thousands of occupants. When the height of building increases, the consideration of stiffness is very important in tall building. In such case outrigger beam is proposed to be provided in between the shear wall and external columns to improve satisfactory lateral stiffness to the structure. The main intention of this research was to optimize the location of Outrigger for safety against Earthquakes and Economy in design. For this purpose, researchers have considerd 9 previous earthquake records and based on acceleration to velocity ratios (A/V Ratio) namely, Park field (28 June 1966), Friuli (6 may 1976), Patras (29 Jan 1974),
Gazli (17 may 1976), El Centro (18 May 1940), Spitak (7 Dec 1988), Mexico City (19 Sep 1985),
Tabas (13 Sep 1978), San Fernando (9 Feb 1971).
The performance of high rise building has been examined by studying different configurations of outrigger structural system. A model of 50 stories was analyzed for three different ratios of peak ground acceleration to peak ground velocity. Response spectrum analysis was conducted to determine behavior of the building considering parameters such as lateral displacement and inter storey drift. It was proved from this study that the structure is optimized when the outrigger is placed between 22-24 levels. Therefore, it can be concluded that the optimum location of the structure is between 0.44-0.48 times its height (taken from the bottom of the building).

Abbas Hangollahi et al., (2012)

In this research paper they worked for high rise steel frame building structure, subjected to seismic load for optimize location of outrigger. In this work basic concept to take out study of results obtain from lateral displacement and storey drift by non-linear time historey and response spectrum method. By taking 20 and 25 storey model has been analyzed by considering ground accelerations of several actual earthquakes in earlier period study about drift and displacement. They have taken 0.44 times and 0.5 times of stature of building as from top. By employing non- linear time historey analysis, the optimum location of outriggers and belt trusses were on high storey14 and 16. So accordingly the researcher it may be secure that outriggers optimum location must be placed at high level.

Kiran Kamath et al., (2012)

In this paper researchers have worked on the differential column shortening due to long term effect in tall building by using outrigger structural system. The basic idea for this research is that the cumulative differential shortening of columns causes the slabs to tilt with resulting rotation of partitions. It is very important to study the effect of column shortening and need special consideration in design. The primary objective of this research was to find out the optimum location of outrigger in high-rise RC building to reduce differential column shortening.

In this research work researchers have analyzed a 60 storied 3-dimensional model with various configurations of outriggers with different H/h1 ratios. From the analytical investigation it is observed that the differential shortening was decreased by 34% when one outrigger system was introduced at H/h1 = 1.715 as well as the same model was analyzed by keeping one outrigger fixed at its optimum position with H/h1=1.715 and second outrigger optimum position is found to be at H/h2=1.33 which will further reduce the differential shortening by a total of 58% so this study conclude that differential shortening of columns was reduced to a great extent by introduction of outriggers.

Halkure S.A. et al., (2014)

In this paper they investigated on irregular shape structure on effect of seismicity in tall rise buildings reinforced concrete building. They researched to study on response of irregular shape structure which will reduce displacement through shear wall to increase the stiffness of building. In tall building it is very important to identify the effective, efficient and ideal location as well as orientation of shear wall.

The researcher took 11 storey structure of irregular with unsymentry structure while comparative analyzed by equivalent force method as per I.S codes, by introducing shear wall with 14 different configurations by changing their percentages of length of shear wall with their possible combination of location of shear wall. Accordingly, the model which gives good seismic response when subjected to earthquake load by considering parameters, such as top displacement, base shear, beam moment and column moment, storey drift and torsion is figured out.

From the whole investigation study, researchers have found that application of shear wall about 23-31% of perimeter structure was found very much effective in controlling displacement.

Gururaj et al., (2014)

In this paper they have focused on the effect of floor which has different loads i.e. mass irregularity in multi-storeyed reinforced concrete building. The main objective of this research work was to examine the seismic response of high-rise building by performing various seismic analysis methods, such as Equivalent static analysis, Response Spectrum analysis and Time Historey Analysis by considering Earthquake data of BHUJ Earthquake (Jan 26, 2001) and KOYNA Earthquake (Dec 11, 1964) to know the realistic behavior during earthquake. So in this research work researchers have modelled 10 storied RCC Building and performed seismic analysis as per Indian Standard Code by different methods as mentioned above to examine the performance of multi-storey building by considering parameters of base shear and storey displacement.

The complete comparative analysis reveals that, to know the non-linear behavior of the irregular structure, the time historey analysis must be performed

Vijaya kumara gowda M.R et al., (2015)

The researcher has worked on lateral load resisting system by adopting belt trusses at top and mid height of building. This proves to more rate to get better their recital of structure subjected to seismic load. Mainly belt trusses which provide all along their tangential column of building at minimum height of structure to develop the firmness with stiffness next to lateral loads. The researcher has carried out by study of using several of belt trusses which include likely X, V, inverted V diagonal, etc. for different earthquake zones criteria to know the importance of belt trusses.

To study, researcher had modeled 30 storied 3D models by implement various type of belt trusses and model analyzed for equivalent static method and response spectrum method as per IS code. Each type of trusses gives different results for different seismic zones, therefore based on economic conditions researchers have concluded that inverted V-type of belt truss is one of the best type of belt truss in all seismic zones to increase the efficiency of the building.

Alpana L. Gawate and J. P. Bhusari (2015)

In this paper they investigated on irregular shape structure on effect of seismicity in tall rise reinforced concrete buildings. They researched, to study on reaction of irregular twisted building that has to reduce displacement through shear walls to increase the stiffness of building. In tall buildings to recognize the efficient of ideal place as known their location of orientation of shear wall. The researcher took 12 storey structure of irregular with unsymmetry structure while comparative analyze by equivalent forces process as per I.S codes, through introducing shear wall with various configuration via changing their percentages through length of shear wall with their possible combination of shear wall and their location. Such parameters like displacement, beam moment, column moment, base shear and storey drift is figured out.

Shivshankar K et al., (2015)

In this paper, they have involved outrigger structural system, in tall vertical regularity structure while parallel dimensions of lateral forces resist method are above more than 15% of nearby storey. In this study, for 30 storey model having vertical irregularity has taken. Here model changes at 11th and 21th storey. And analyzed for single bare frame and bare frame through outrigger and belt trusses by changing their position at six configurations as usually bare frame at two outrigger of belt trusses of 5 different configurations and evaluated under various parameter. It was recognized through this research that around 28.58% and 27% lateral deflection and building drift was restrain by providing outrigger structural system in high rise vertical irregularity structure when it is provided at 0.67 times its height compares to bare frame as well as 37.7% and 36.11% of the Deflection and drift is controlled by providing outrigger with belt truss at 0.67 times its height and 0.5 times it's when compared with bare frame. To examine the behaviour of vertical irregularity of outrigger structural system, linear static analysis has been carried out as per the Indian standard.

Thejaswini R. M. et al., (2015)

In this research paper they have studied comparative study and analysis of various lateral load resting of structural system toward known the practical concert of structure while during seismic activity due to extreme wind anxiety to decide on type of structural system through high rise structure to keep in superior state by an cause of live load and lateral load, at instant and shear forces through an certain force and stiffness.

In paper they have modelled a geometrically irregular 14 storey RCC high rise building with different forms of structural system, such as Rigid frame structure, Core wall structure, and Shear wall structure with different configurations of shear wall location, Tube structure and outrigger structure. Results of the analysis reveal that the values of displacement were less in tube structure and outrigger structural system. The authors have also stated that in geometrically irregular structure; stability of structure will boost and the columns sway can be reduced by implementing L-shaped shear wall along the corners of the structure. One important conclusion that the researchers have drawn from this study is that when outrigger structural system is provided at a storey which has maximum drift, it can perform as a maximum drift controller

Shrinivas B.N et al., (2015)

In this paper they have carried regular and vertical irregular structure to increase axial stiffness at outer column to resist at over turning moment by using steel bracing in outrigger structural system. The researcher had compared analysis for 3-dimensional regular and vertical irregular structure with symmetric plan for 20 storey structure "with and without outrigger beam" subjected to seismic loads.

By analyzing of structure, taking equivalent static methods as per Indian standard code. They have considered parameter, such as storey drift, displacement, fundamental natural time period and base shear. They had various different zones as behavior of outrigger through equivalent static method and response spectrum system by incorporate concert and steel bracing outriggers. And they focus to vary lateral displacement and natural time period. When outriggers had introduced in regular and irregular structure which has improve in stiffens in structure. Base shear will reduce and inner storey drifts too by incorporating outriggers. In vertical irregular, there was further efficient due to reduction of self-weight when compared to regular structure and as by providing X-bracing by reduction of lateral storey displacement was found.

Rahul Y. et al., (Feb 2017)

In this research work they have considered dynamic analyze of tall rise steel by shear wall. The outrigger performs to lateral stiffness that provides drift controller for tall structure. They include shear wall, rigid frame, wall frame and outrigger of structure. The main objective is to perform outrigger structural system in tall structure subjected to wind load and seismic loads as per Indian standard codes. They compared on static and dynamic analysis on the conduct of comparative structure of various cases of 50 storey structure by using finite element method. They mainly compared bare frame with steel bracing with center core of structural in efficiency by measured of lateral displacement, storey shear, base shear and time period values. The provision of outrigger along a shear wall increases the force and stiffens of structure against seismic and wind load. And shear walls without openings and by reduction at inner storey drift can be achieved.

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MethodologyAdopted:

Subsequent is to adopted for analysis of outrigger with steel bracing and without outrigger

1) R.C Structure is considered for study having 30storey of height 90m each floor is 3m height.

2) The regular R.C concrete moment resisting frame of square plan with core in center location is measured as base.

3) The floor height as kept steady for all floors to get accurate results.

4) Outrigger has adopted an steel bracing frame, comparing with geometric models.

5) To understand the behavior under lateral loads applied as per IS 1893-2002 are used respectively.

6) Based on the results and response from earthquake load applied conclusions are made.

Model Data:

Structure OMRF
No. of stories G+30
Storey height 3.0 m
Base storey 3.0 m
Plan dimension 2704 m (for regular building) 2421 m (for irregular building)
Grade of concrete M30 and M25
Grade of steel Fe500
Thickness of slab 150 mm
Beam size 550*300 mm 450*300 mm
Column size 1000*1000 mm 900*900 mm
Outrigger Steel Bracing ISA
150*150*15

Modeling

a) Rectangular without outrigger

b) Rectangular with outrigger with steel bracing

c) Hexagonal without outrigger

d) Hexagonal with outrigger with steel bracing

Gravity load:

a. Live-load - 4 kN/m2 (IS-875 (part 1) :1987)

b. Floors-finish - 1 kN/m2 (IS-875 (part 2): 1987)

c. Seismic load - IS-1893 (part 1): 2002

Earthquake inputs as per IS 1893 (Part 1): 2002

Soil type- Type II
Importance factor- 1.0
Response reduction factor - 5.0
Seismic Zone- IV (0.24)

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Objective of the Study:

a) To model and analyze the structure and to get mainly effective structure to resist lateral loads.

b) To study the use of outriggers in an regular and vertical irregular structure under seismic force.

c) The buildings with and without outrigger are compared.

d) To acquire behavior of outrigger introduced as a steel bracing in a R.C tall structure.

e) To compare the effect of outriggers by both Equivalent static method and Dynamic Analysis method (Response spectrum method) as per IS 1893 – 2002.

f) To study parameters such as storey shear, displacement, storey drift, storey stiffness, fundamental natural time period and base shear.

Conclusion:

1 From above study we can observed that the displacement is depending on the geometry of the structures.

2. In the present study we can see that all the results obtained are within the limits as per the codal limitations.

3. The system of outriggers in the structure increase the effectiveness of the structure when compare to structure without outrigger in the action of lateral loads.

4. The structure increases flexural stiffness with providing outrigger, it plays the major role in structure while reducing base shear in static and dynamic loads.

5. The outrigger member increases their sizes, displacement in tall structure system decreases. The shear wall provided at center core with adopting outrigger in tall structure decreases forces in core.

6. The behavior of structure in the seismic loads is various for different structure.

7. The upper storey of structure get reduction in displacement is less compare at outrigger adopted at 1/3rd of floors.

8. The outriggers are used various zones as per seismicity.

9. The outriggers are adopted as X-steel bracing as it gives better output on tall structure it minimizes lateral load.

10. The outrigger in tall structure it reduced storey drift.

11. The symmetry and asymmetry of floor its minimized its self-weight of structure.

12. The present study of work compares the differences in the behaviors of the building when outrigger is used.

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